BULLETIN ~~90-240-13~~ 90-49-09

Fp

CONTROL CENTER FOR MILWAUKEE'S WATER WORKS

by

ARTHUR RYNDERS
Superintendent of Water Works,
Milwaukee, Wisconsin

and

ALAN L. VINK
Senior Systems Engineer,
Fischer & Porter Company,

FISCHER & PORTER COMPANY
HATBORO • PENNSYLVANIA

Reprinted from PUBLIC WORKS Magazine
Vol. 90 No. 10 October 1959

CONTROL CENTER

FOR MILWAUKEE'S WATER WORKS

ARTHUR RYNDERS
Superintendent of Water Works,
Milwaukee, Wisconsin

EXPERIENCE over a period of years has indicated that there is much to be desired in the flow of operating information within water utility systems. Desirable factors are: 1) the collection of information on which to make operating decisions; and 2) the transmission of these decisions in the form of operating instructions.

Our existing facilities consisted of commercial telephones in each of the operating facilities; a water utility radio system with a console in the Water Distribution Division office with receiver-transmitters in 14 of our trucks; and a few liquid level transmitters between storage and pumping facilities.

Looking for improved methods we found many ideas, two of which were of particular interest. One was the centralized information and dispatch system in the Atlanta Water Works and the other was the data logging equipment shown at the AWWA convention in Dallas, Texas. Keeping in mind all that we had seen and heard, we proceeded to assemble our ideas.

First of all, we decided upon a name—Control Center. Its function was determined to be the control of the operations of the water utility to the end that better water service would be rendered to the customers.

The Center, in the new City Hall Annex, is on a floor used almost exclusively by the water utility. It is manned by dispatchers 24 hours a day with a Chief or Deputy Chief of Water Works Operation available at all times. All the maps, atlases, plans, data, etc., which may be required for every conceivable operating situation, are arranged for quick and easy reference.

The means provided for the flow of information are of five principal types: 1) Data logging—27 bits now, 3 more soon and 17 more in 1961; 2) telephones—Water and Utility PBX; 3) radio, including transmitter, receivers at principal stations, certain supervisors cars and numerous trucks; 4) written—typed and longhand; and 5) charts from outlying points in the distribution system.

Specifications for the data logging system were prepared by the Water Engineering Division. In accordance with Milwaukee standard practice, the work of furnishing and installing the data logging equipment was advertised. The Fischer & Porter Co., being the low bidder, was awarded a contract which was completed within the specified time. At this writing the installation is operating under a 60-day guarantee period.

The accompanying article, by Alan L. Vink, describes: 1) the data logging system actually installed; and 2) how the system works.

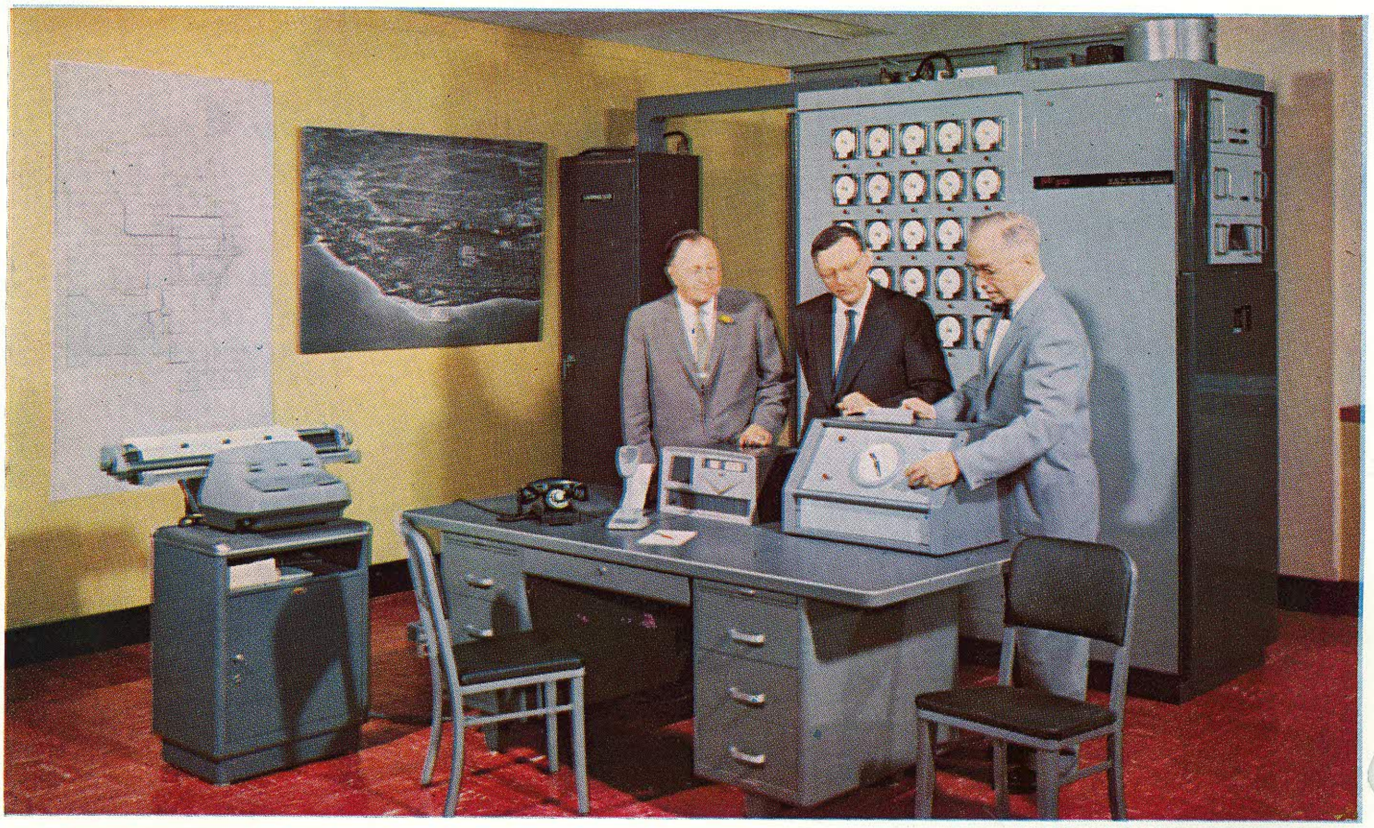


Photo courtesy Fischer & Porter Company

● OPERATION of the centralized electronic data logging system at the Milwaukee Water Department control center is demonstrated by the author to Mayor Frank P. Zeidler (center) and Lloyd D. Knapp (left), Commissioner of Public Works.

ELECTRONIC INFORMATION SYSTEM
PROVIDES CENTRALIZED RECORDS AND OPERATIONAL CONTROL

ALAN L. VINK
Senior Systems Engineer,
Fischer & Porter Company,
Hatboro, Pennsylvania

A NEW $100,000 centralized electronic data telemetering and recording system is helping Milwaukee get the most out of its present water utility system. The new information system measures 27 critical pressures, flows, and water storage levels at 12 widely-separated stations, telemeters the information over telephone lines to a central Operations Center, and records it automatically by typewriter. Equipment for three more units are on order. It is the first such automatic recording system to go into operation in a water utility in the U. S. The primary measuring instruments and the data recording equipment were designed, manufactured and installed by Fischer & Porter Company, Hatboro, Pa. Telemetering equipment was made by Hammarlund Manufacturing Co., Inc., New York.

Despite the fact that Milwaukee lies adjacent to one of the largest fresh water reservoirs in the world —Lake Michigan—the water problem is and will continue to be critical until a $54,000,000 expansion program is completed and in operation. Due to the saucer-like topography of Milwaukee, outlying areas are the highest, which adds to the pumping problem. Moreover, Milwaukee, like most other American cities, has experienced a rapid growth rate in recent years—in industry, area and population. The effect of this growth on the Milwaukee water system during the period 1953-58 can be seen in Table 1. In 1952, 732,800 people were being served. Five years later, this figure had reached 836,200, an increase of 14.11 percent. This rate of growth promises to continue without letup, and may even increase. In addition, with Milwaukee now a seaport, industrial water consumption is expected to increase greatly.

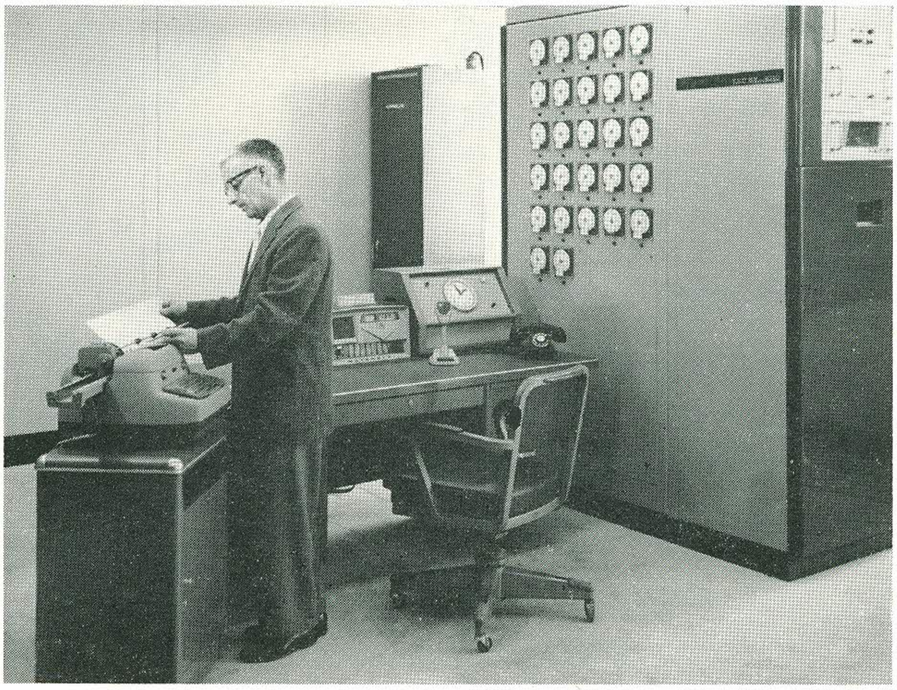
All of these factors—population growth, industrial growth and geographical growth—point to increased water consumption. Thus, more than ever before, Milwaukee officials must know exactly where they stand and where they are going.

In order to understand just what the new information system does, it is desirable to have some familiarity with the Milwaukee water system. The system is divided into two areas. Downtown Milwaukee near Lake Michigan is the low service area. The rest of the city, plus suburbs and outlying communities, is the high service area.

All water for Milwaukee is obtained from an intake through a 12-ft. concrete tunnel which extends 6565 feet into the lake from the 24-acre water purification plant

Table 1—Expansion of Milwaukee Water Works System 1952-1958

	From 12-31-52	*To 12-31-57*	*Numerical Increase 1952-1958*	*Percent Increase 1952-1958*
Est. Population (city only)	646,000	714,000	68,000	10.53
Population supplied (including suburbs)	732,800	836,200	103,400	14.11
Total Services	147,302	178,936	31,634	21.48
Miles of Main	1,435.99	1,797.22	361.23	25.16
Average daily consumption (gallons)	129,177,049	141,742,770	12,565,721	9.73
Hydrants in service	10,438	13,272	2,834	27.15



● **CONTROL CENTER of the Milwaukee Water Works is manned by an operator at all times. In the event of an emergency condition anywhere in the system, the source of the trouble can be detected from the readout record and service units dispatched.**

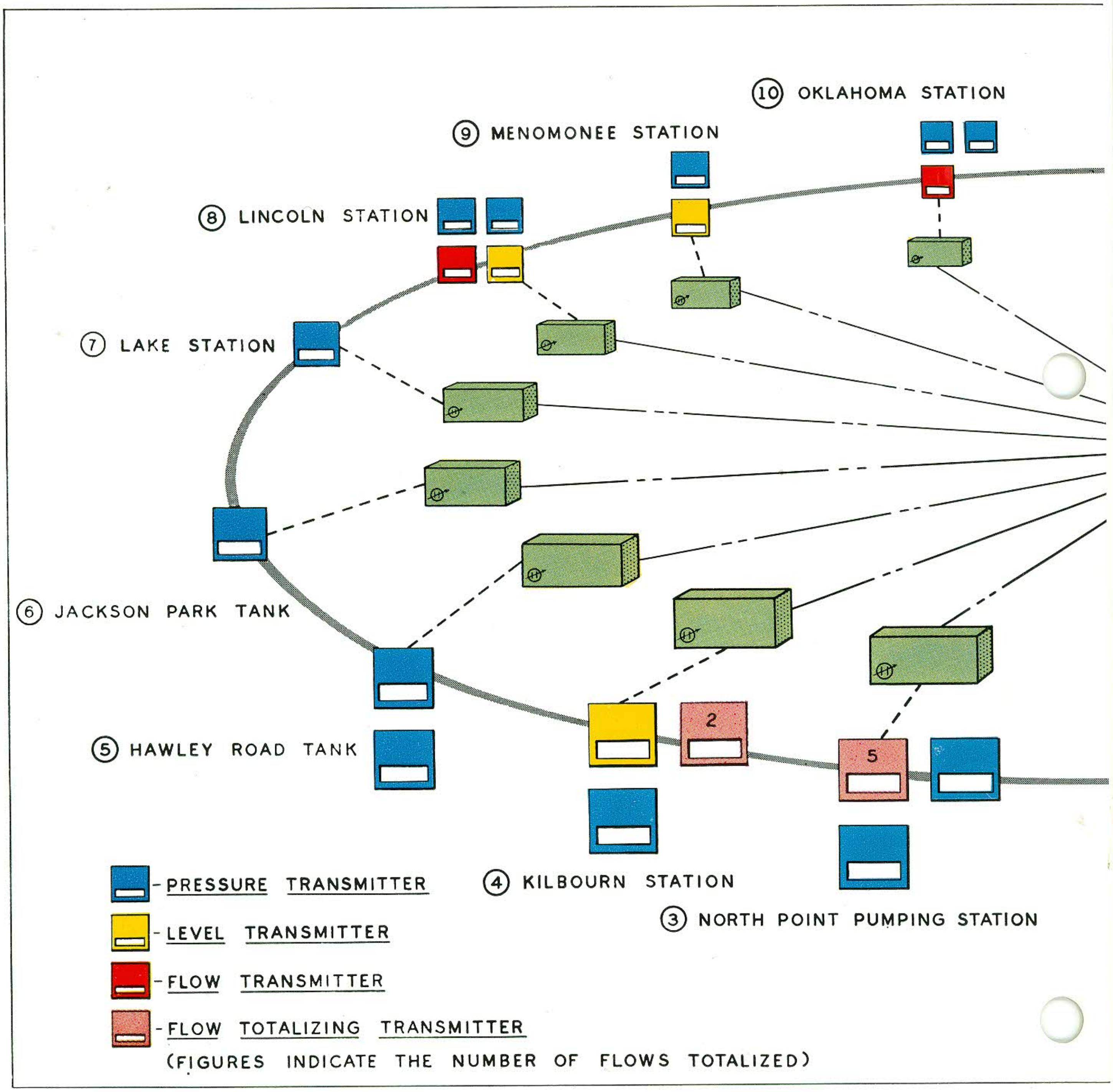
(point 1 on the diagram) located on the shore of Lake Michigan. The depth of water at the intake end of the tunnel is 67 feet. At this point, the tunnel is 150 feet below the level of the lake. A lake shaft with an internal diameter of 12 feet extends upward from the end of the tunnel to the intake. The inlet is protected by a submerged octagonal intake crib, 80 feet in diameter and 12 feet in height.

The water purification plant which utilizes rapid sand filtration, has a rated capacity of 200 mgd. However, it can be operated as high as 300 mgd. The plant consists of two coagulation basins, a filter building with 32 filter beds, and three filtered water reservoirs: one 13 mg, one 9.65 mg and the other 7.33 mg. Water is pumped from the purification plant to Riverside (2) and North Point pumping stations (3).

North Point pumping station has an installed pump capacity of 126 mgd with four pumps supplying water to the low service area including Kilbourn Reservoir (4). Another four pumps serve the high service area during peak periods in conjunction with Riverside.

Riverside pumping station is the key station for the entire high service area. It has an installed pump capacity of 264 mgd. It delivers to the high area, including the 1 mg reservoir at Lake Station (7), Jackson Park elevated tank (6) with a capacity of 1½ mg and Hawley Road elevated tank (5), also with a capacity of 1½ mg.

In addition, there are two booster pumping stations, Lincoln station (8) and Menomonee Valley station (9), both with storage reservoirs, 12 mg and 18 mg respectively. Three booster stations, Oklahoma (10), Bluemound (11) and Capitol (12), plus portable pumping units, complete the system.



● **CENTRALIZED Information System of the Milwaukee Water Works collects pressure, water level and flow data from**

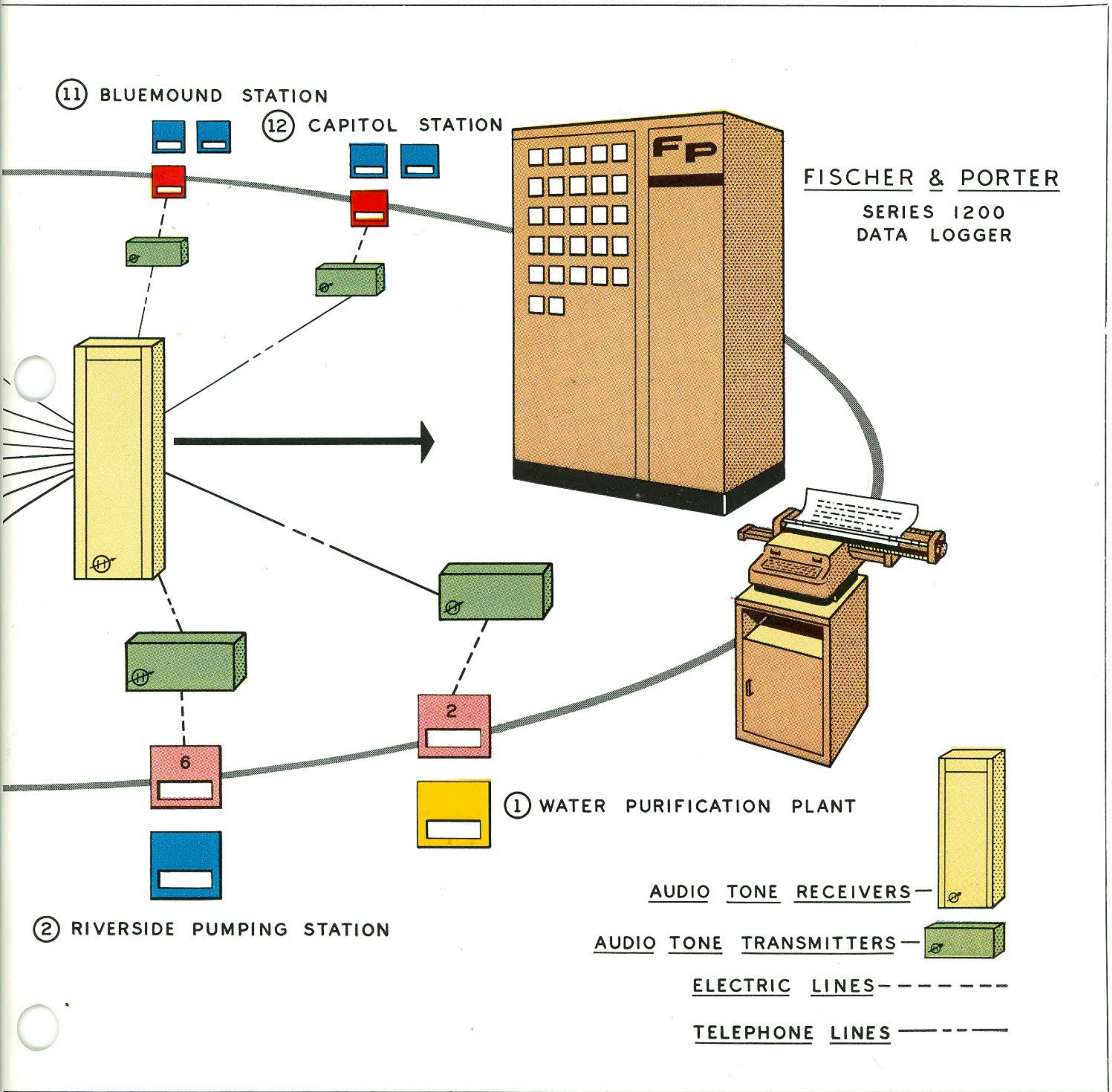
At night, all reservoirs are filled to capacity. During the day, the pumps are able to handle demand until late afternoon, when it becomes necessary to draw from the tanks and reservoirs. These remain on the system until about 10 P.M. when it becomes possible to start filling the tanks again.

Average daily consumption ran about 142 million gallons during 1957. On peak days it is necessary to pump over 200 million gallons, and at such times, the system is operating beyond the rated capacity of the water purification plant.

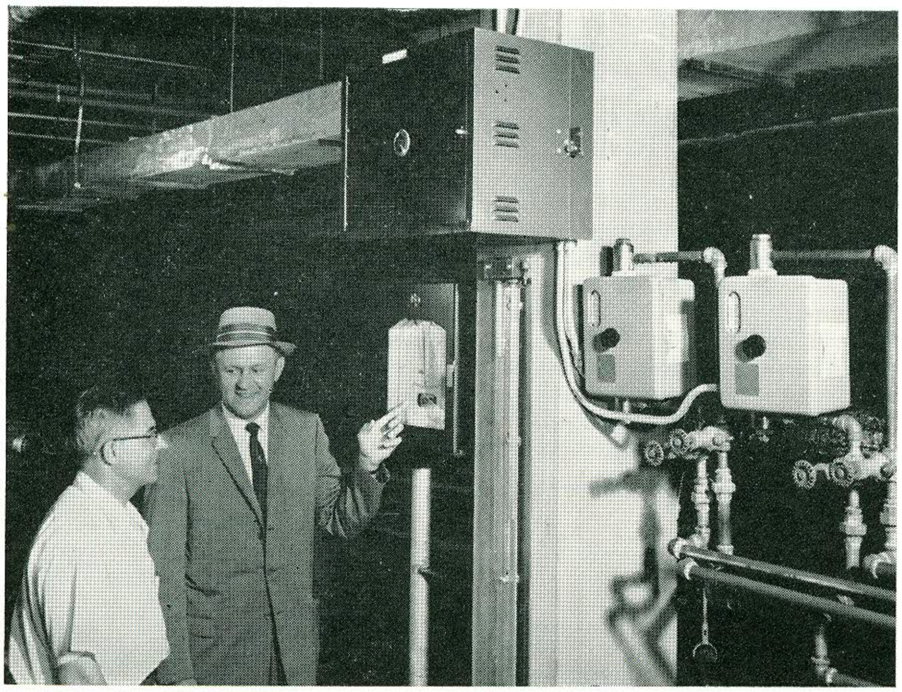
Operation of any water system over capacity naturally causes problems. It is necessary to stay alert for main breaks, low pressure areas, and other abnormal or subnormal conditions that would lower the quality of service or disrupt it entirely.

Before installation of the Information System, conventional chart recording devices located at various points were used. The "chart crew," as they were called, made the rounds of these instruments and checked them. If a serious condition existed, the man would call the Distribution Center. Distribution would then dispatch a radio service truck or car to the trouble point. Unfortunately, the weak link in this chain was the time it took to spot the trouble initially. It takes time to travel around from point to point checking records. Sometimes trouble would be reported by citizens before the records were seen.

Now, if there is a breakdown or drop in flow, it is evident instantaneously through the record provided by the Information System. Often, potential trouble can be detected even before it develops. The old saying about "an ounce of prevention" is as true for water utility operation as for anything else.



twelve remote stations. At the Control Center the Data Logger feeds these data to the automatic readout typewriter.



● **TWO V/A CELLS (flow measuring instruments) at the Purification Plant are shown at the right. Walter Wendt, Water Plant Design Engineer, points to the flow totalizing transmitter. The dual tone transmitter is mounted on column at top.**

The Fischer & Porter Telemetering & Data Recording System (refer to the diagram)consists of: a) The necessary transducing instruments to measure, indicate, and/or record locally and to retransmit flow, level and pressure values; b) the telemetering facilities for distant transmission and reception of these signals over telephone lines; and c) the data recording equipment required to convert and record these signals in digital form (typewritten log sheets).

Instrumentation

There are four basic types of Fischer & Porter instruments used in the system:

V/A Cell Ori-Flowrators. These instruments, thirteen in all, are kinetic manometer type flowmeters. They measure bypass flow as a function of main line flow across a set of orifice taps. Main line flow is indicated on a linear scale and an electrical signal linearly proportional to main line flow is transmitted to a suitable receiver.

In operation, bypass flow passes through a variable area metering tube in which a float is located. The velocity of the flow lifts the float within the tube and the position of the float indicates the flow rate. Through a magnetic bond, a follower arm is positioned by the float. A pointer attached to the follower arm provides a visual indication on a segmental scale and, through a linkage, movement of the follower arm positions the armature of a differential transformer which determines the output voltage of the instrument.

This electrical output, which is linearly proportional to flow rate, is transmitted electrically to one of the flow totalizing transmitters described below.

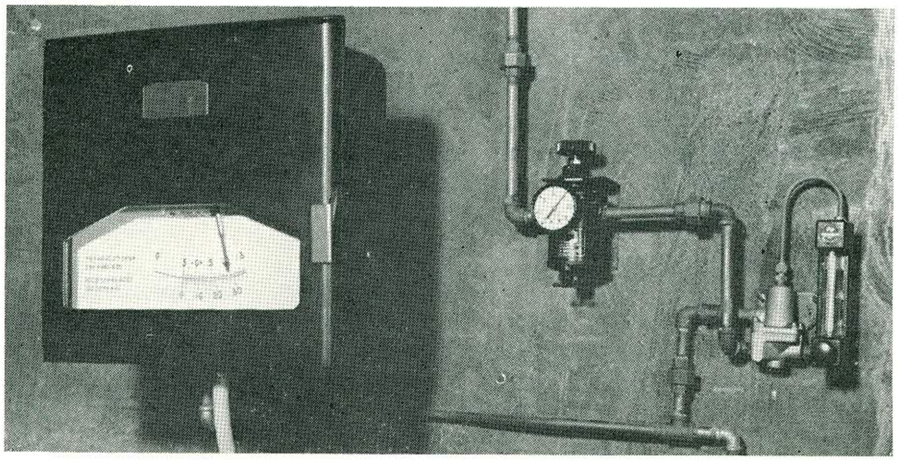
Flow Totalizing Transmitters. These are secondary instruments in the sense that they do not actually measure the process variable, but accept electrical inputs from the V/A Cells. There are four of them in the system. They indicate and transmit a pulse time signal proportional to the sum of the V/A Cell inputs.

Each of the totalizers contains a differential transformer similar to the one in the V/A Cell. This is held in balance with the sum of the V/A Cell inputs by means of a servo motor operated by an electronic amplifier. The position of the armature of the differential transformer in the totalizer is indicated by a pointer to provide visual readings of the summed flow rate. In addition, the armature position determines the duration of the electrical pulse produced by a pulse time transmitter connected to the totalizer. The total time cycle for each signal is 15 seconds. At mid position, the pulse is on for 7½ seconds and off for another 7½. If the process signal level changes, a pulse of different on-off duration results, but the total time cycle remains at 15 seconds.

Level and Pressure Transducers and Flow Transmitter. These instruments measure, indicate and transmit pulse time signals proportional to the measured process variable. There are four level transducers, seventeen pressure transducers, and one flow transmitter. Each level transducer has an enclosed bellows receiver to convert pressure to spindle position. The pressure transducers sense pressure by means of a spiral Bourdon element which converts pressure to a shaft position. The shaft is connected to the instrument spindle. Thus, ultimately the result is the same.

The flow transmitter, installed at the Kilbourn station, is the secondary instrument which receives a pneumatic process signal from a relay averaging signals from two previously existing primary flow measuring instruments. It uses the same principle as the level transducer, an enclosed bellows receiver. The instrument spindles of all of these instruments are connected to pointers which indicate readings visually. Spindles are linked to pulse time transmitters as described above.

Mercury Manometer Flow In-

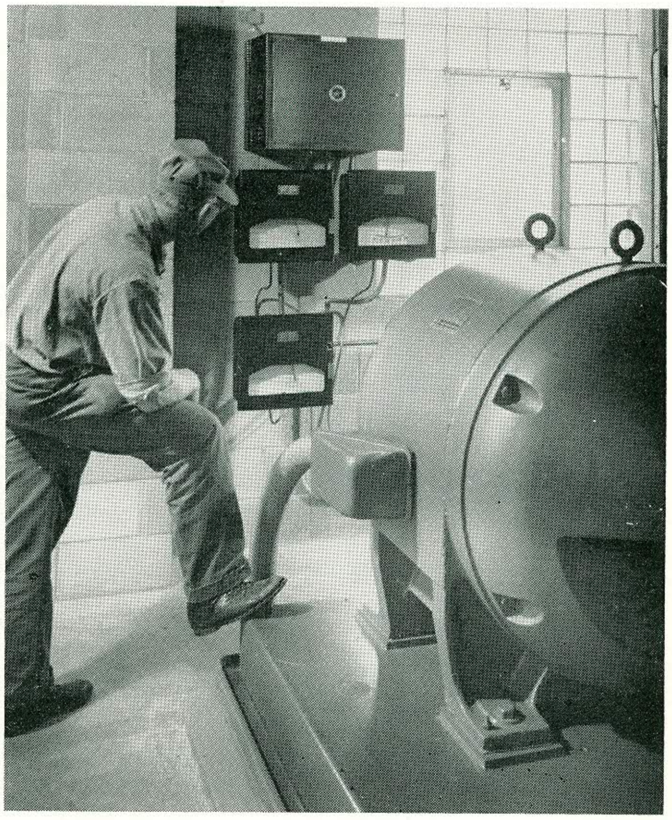


● **WATER STORAGE level at the Purification Plant is measured, indicated and transmitted by this instrument. Double scale indicates both the storage and level.**

dicating Transmitters. These primary instruments, four in all, measure flow rate in terms of the differential pressure produced across an orifice plate. Changing pressure differentials move a buoyant float in a mercury filled U-tube manometer. As the mercury level changes, a linkage connected to the float through a magnetic bond positions the instrument spindle according to the flow rate. The spindle is provided with a pointer to indicate the flow visually and is linked to a pulse time transmitter.

Milwaukee Journal photo

● **TONE RECEIVER indicating units mounted on the Data Logger at the Control Center are inspected by Elmer Becker (left), Asst. Superintendent of Water Works, and Mr. Wendt.**



● **INSTRUMENTATION at the Kilbourn Pumping Station and Reservoir. Top unit is the Hammarlund tone transmitter; below this are the station's pressure, level and flow transmitters.**

These are the four basic types of instruments used to measure, indicate and transmit flow, pressure and level values at the twelve remote stations in the Milwaukee Water Works Centralized Information System. Pressure and level instruments have two scales. The upper scale indicates Feet Above City Datum (FACD) and the lower scale indicates psig or million gallons of stored water (MGSW).

Instruments are as follows:

1) WATER PURIFICATION PLANT

Two V/A Cells	0 to 200 MGD
Flow Totalizing Transmitter	0 to 400 MGD
Level Transducer	0 to 36.4 MGSW (0 to 31 FACD)

2) RIVERSIDE STATION

Two V/A Cells	0 to 40 MGD
Two V/A Cells	0 to 70 MGD
V/A Cell	0 to 90 MGD
V/A Cell	0 to 50 MGD
Flow Totalizing Transmitter	0 to 380 MGD
Pressure Transducer	0 to 150 psig (0 to 375 FACD)

3) NORTH POINT STATION

Two V/A Cells	0 to 29 MGD
Flow Totalizing Transmitter	0 to 58 MGD
V/A Cell	0 to 45 MGD
V/A Cell	0 to 23 MGD
V/A Cell	0 to 60 MGD
Flow Totalizing Transmitter	0 to 128 MGD
Two Pressure Transducers	0 to 150 psig (0 to 375 FACD)

4) KILBOURN STATION

Pressure Transducer	0 to 40 psig (0 to 220 FACD)
Level Transducer	0 to 29 feet (0 to 159 FACD)
Flow Transmitter	0 to 50 MGD

5) HAWLEY ROAD ELEVATED STORAGE TANK

Two Pressure Transducers	0 to 70 psig (0 to 295 FACD)

6) JACKSON PARK ELEVATED STORAGE TANK

Pressure Transducer	0 to 80 psig (0 to 275 FACD)

7) LAKE STATION

Pressure Transducer	0 to 70 psig (0 to 310 FACD)

8) LINCOLN STATION

Two Pressure Transducers	0 to 125 psig (0 to 365 FACD)
Level Transducer	0 to 15.1 MGSW (0 to 115 FACD)
Mercury Manometer Flow Indicating Transmitter	0 to 40 MGD

9) MENOMONEE STATION

Pressure Transducer	0 to 150 psig (0 to 360 FACD)
Level Transducer	0 to 21.7 MGSW (0 to 57 FACD)

10) OKLAHOMA STATION

Two Pressure Transducers	0 to 150 psig (0 to 500 FACD)
Mercury Manometer Flow Indicating Transmitter	0 to 4 MGD

11) BLUEMOUND STATION

Two Pressure Transducers	0 to 150 psig (0 to 475 FACD)
Mercury Manometer Flow Indicating Transmitter	0 to 4 MGD

12) CAPITOL STATION

Pressure Transducer	0 to 54 psig (0 to 290 FACD)
Pressure Transducer	0 to 100 psig (0 to 400 FACD)
Mercury Manometer Flow Indicating Transmitter	0 to 8 MGD

Choice of Instrumentation

Instruments were chosen for accuracy, simplicity, and economy—in that order. Since an accuracy of 1.5 percent average with a maximum deviation of 2 percent was required, instrument accuracy was the primary consideration. Simplicity is directly related to accuracy since in any complex system the greater the number of components, the more potential sources of error. Simplicity, therefore, was emphasized as a secondary consideration. Economy, in turn, is directly related to simplicity and accuracy. Usually, the more complex a given system, the higher the cost. Also, the higher the degree of accuracy the greater the cost.

One of the most important engineering factors determining choice of specific instrumentation was the fact that signals were to be transmitted from the remote stations to the central operations center over telephone lines. This dictated that signals lie in the range of human audibility. Since Hammarlund Manufacturing Company is a recognized leader in the field of audio tone telemetry, their equipment was chosen. Naturally, the use of an audio tone telemetering system had a bearing on the choice of instruments.

Telemetering Equipment

The signals from the various F & P measuring instruments are transmitted electrically to the Hammarlund Tone Transmitters (with the exception of the V/A Cells which are first totalized and the totalized signal transmitted). There are eighteen transmitters, in all, located at the twelve remote stations. Fourteen are dual channel transmitters and four have a single channel. Since thirty points are being monitored at present, two channels remain available for future use.

The transmitters generate an audible tone pulse (or in the case of the dual channel transmitters, two tone pulses), the length of which is determined by the Pulse Time Transmitter. These pulses are amplified and transmitted from the remote stations to the central operations center. In the present system, a single pair of telephone lines is used to transmit the information from each station.

Control Center Equipment

At the Control Center the tone signals are received from the twelve remote stations and read out in the form of a typewritten record. Equipment installed at the Control Center consists of:

a) Thirty Hammarlund tone signal receiving units, each preset to the exact frequency of the transmitter with which it is "mated."

b) The Fischer & Porter Series 1200 Data Logger, which is a complete data reduction system for automatically scanning, measuring, memorizing, and reading out process variables as digital values. The logger reads out automatically at preselected intervals, or readout can be initiated at any time simply by pressing a button. If desired, the logger can be set for continuous readout over and over with no time lapse between readouts. The F & P logger features a pinboard program selector in which the position of the pins determines the sequence of readout, the mathematical functions applied to each, the number of times a given point is read in a given time period, points monitored for alarm conditions, high and low alarm settings, and other logging characteristics. The system presently logs information on thirty variables emanating from twelve remote stations; however it can be economically expanded to one hundred points simply by the use of additional plug-in sub-assemblies.

How the System Works

The big advantage of the new Information System is that it provides a centralized, simultaneous record of all critical points in the Milwaukee water system. Information is transmitted almost instantaneously and data are read out in typewritten form on a single log sheet. Thus, where it used to take up to 24 hours to learn of an undesirable condition, water works officials now are alerted almost immediately and can take corrective action.

Since all points appear simultaneously side by side on the log sheet, the department has a true comprehensive picture of what is going on in the Milwaukee water system.

Not only does this help keep the presently overloaded system functioning smoothly, but it is anticipated that the hour-by-hour record of the functioning of the water system will prove extremely useful. Analysis and correlation of these records should provide much valuable data.

It is expected that, with the aid of the data logging equipment the water utility will be able to provide better service to its customers.

FISCHER & PORTER CO.
Instrumentation and Chlorination

Pub. 13351

Printed in U.S.A. Oct. 1959